Matching Review and Coding System for Accuracy and Coverage Evaluation (Housing Unit, Person and Final Housing Unit) System Requirements Study

FINAL REPORT

This evaluation study reports the results of research and analysis undertaken by the U.S. Census Bureau. It is part of a broad program, the Census 2000 Testing, Experimentation, and Evaluation (TXE) Program, designed to assess Census 2000 and to inform 2010 Census planning. Findings from the Census 2000 TXE Program reports are integrated into topic reports that provide context and background for broader interpretation of results.

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PREFACE

Purpose of the System Requirements Study

The main objective of the System Requirements Study is to assess the efficacy of the requirements definition processes that were employed by the U.S. Census Bureau during the planning stages of the Census 2000 automated systems. Accordingly, the report's <u>main focus is on the effectiveness of requirements methodologies</u>, including processes for <u>coordination, communication, and documentation</u>, and their impact on overall system functionality. The report also addresses certain contract management issues and their effect on system development and/or operational considerations.

The System Requirements Study synthesizes the results from numerous interviews with a range of personnel--both U.S. Census Bureau staff and contractors--who were involved with the planning, development, operations, or management of Census 2000 systems. Our findings and recommendations in this report are qualitative in nature; they are based on the varied opinions and insights of those personnel who were interviewed. The intent is to use the results from this study to inform planning for similar future systems.

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EXECUTIVE SUMMARY

The Accuracy and Coverage Evaluation is a survey and coverage methodology designed to assess the size and characteristics of the population missed or double-counted in Census 2000. The methodology is designed to develop an independent estimate of persons and housing units for use in producing and evaluating the final census results. The Matching Review and Coding System is software designed to facilitate clerical matching of records between census data and Accuracy and Coverage Evaluation data. The system supports clerks, technicians, and analysts at the National Processing Center, as well as users within the U.S. Census Bureau Headquarters. This study presents information based on debriefings with personnel involved with the Matching Review and Coding System.

A character-based system was developed by in-house resources and used for the Census 2000 Dress Rehearsal. This system lacked sufficient functionality to meet the needs of the matching process. A decision to outsource development of a new system that could provide the point and click interface of Windows-based software was made. A statement of work was developed and three vendors were evaluated. Gunnison was selected based on its experience in developing the Clerical Person Matching and the Master Address File/Quality Improvement Program software products for the U.S. Census Bureau. The Matching Review and Coding software was developed, successfully deployed, and considered by those involved in the study to be the "right system for the job." Although some requirements changed over time and new requirements were introduced, the dedication of the contractor and agency personnel resulted in a successful system development effort. This was accomplished despite significant time and resource constraints. Major results of the study include:

- **Incremental development process was used.** The software was developed as three distinct systems. This enabled U.S. Census Bureau personnel and developers to build upon their experiences and apply critical lessons learned during the development process. Although the same general process was used to identify, clarify, and implement requirements across the systems, the procedures and means of communication were fine-tuned over time.

- **Windows-based software is easy to use.** The software provides point and click functionality to facilitate the clerical matching process. The software is more streamlined than earlier systems allowing the clerks to move faster through the matching process. Technological improvements such as split screen and filter capabilities also enhance the system's usability.

These and other findings have led to the following key recommendations:

- **Team building - conduct team training.** A team approach was utilized to identify requirements and evaluate the software. A team approach enables the organization to solicit different viewpoints and ensure that the widest range of needs are addressed.

Team members should receive training in team concepts and effective communication and participate in team building exercises in order for the team approach to be most effective.

- **Test planning - clarify roles and responsibilities.** Several testing processes were implemented between the contractor, alpha test groups, and the U.S. Census Bureau Beta Test Site. Care must be taken to clearly identify the roles and responsibilities of each group and procedures must be established to ensure an effective and efficient means of sharing test results. This will help ensure conformance with requirements specifications and comprehensive coverage of testing needs.

1. BACKGROUND

The Titan Systems Corporation, System Resources Division (Titan/SRD) was tasked by the Planning, Research, and Evaluation Division (PRED) of the U.S. Census Bureau to conduct system requirements studies for 12 automated systems used in the decennial census. This report is a study of the Matching Review and Coding System (MaRCS) for the Census 2000 Accuracy and Coverage Evaluation program. It addresses the extent to which the requirements definition process was successful in identifying the needed system functionality and offers one of several evaluation approaches for examining these automated systems. The report results are intended to assist in the planning of similar systems for the 2010 Census.

The Accuracy and Coverage Evaluation (A.C.E.) is a survey and coverage methodology designed to assess the size and characteristics of the population missed or erroneously enumerated in Census 2000. A.C.E. incorporates several interrelated field and processing operations; it is designed to develop an independent estimate of persons and housing units for use in evaluating the final census results. The concept was originally part of the Integrated Coverage Measurement (ICM) program.

A.C.E. identifies a listing sample of about 750,000 housing units. Field representatives systematically canvass block clusters during the A.C.E. Listing operation in order to create an address list that is independent of the census address list. After sample reduction, the A.C.E. universe is reduced to approximately 300,000 housing units to interview. A comparison is then made between the two lists to identify the housing units which are common (or match) between the two lists. Differences are resolved as part of the Housing Unit Followup (HUFU) operation. After HUFU, sample addresses are prepared and used to create input files for the Person Interview (PI). A comparison of the person files is made and differences between A.C.E. and census person data are then resolved in the Person Followup (PFU) operation. Activities include: conduct independent listing; key listing books; match and followup housing units; create enhanced list; conduct A.C.E. Person Interview (PI); conduct A.C.E. person matching and followup; and match and followup final housing units.

The MaRCS are PC-based survey/data matching systems used to match the census and A.C.E. survey lists of addresses or people. Matching/coding is conducted before and after the HU or PFU operations in what is called the Before Follow-up (BFU) and After Follow-up (AFU) stages of review and coding. Three independent systems were developed: Housing Unit (HU) MaRCS, Person (PER) MaRCS, and Final Housing Unit (FHU) MaRCS. The systems were developed using Visual Basic, SQL Server, and MS Access and operate in a Windows NT environment. The systems were developed to conform to software guidelines and complex survey design requirements. Crystal Reports and Grid Wiz are third party tools used to display and print system information. The different systems support up to 350 users including clerks, technicians, and analysts at the National Processing Center (NPC) as well as users at Census Bureau Headquarters (HQ). The number of users vary per system and not all systems support all user types.

These MaRCS systems have several management functions to allow HQ and National Processing Center (NPC) managers to see reports of activity and to allow for Quality Assurance (QA) management. The QA component for MaRCS allows HQ and NPC managers to set parameters to select a sample of the clerk's or technician's work for review at various levels and to approve users for certain types of work. Based on the results of the QA sample, the QA parameters may be modified to assure data quality.

An Evaluation (EVAL) MaRCS also was developed. This system supported about 75 users and was used to evaluate several aspects of A.C.E.

2. METHODOLOGY

The Titan/SRD Team interviewed key personnel for each of the Census 2000 automated systems using a structured approach centered around four fundamental areas. A set of questions under each of those areas was designed to explore: (1) the effectiveness of the requirements definition process; (2) how well the systems were aligned with business processes; (3) identification of any deficiencies in functionality or performance relative to actual operational needs; and (4) how effective the agency contract management activities were in regards to contractor performance.

A similar, but separate set of questions, was designed for contractors who were identified as key personnel. The contractors were asked about the following areas: (1) the clarity of the statement of work and the impact of any changes to the specifications; (2) their interactions with government personnel and the technical direction they received; (3) the timeline for completing the work; and (4) their impressions of the system's suitability and operational effectiveness.

The purpose of the system requirements study is to summarize the results of interviews with key personnel by system. A variety of related system documentation was reviewed in connection with the interviews. The assessments provided in Section 4., Results, reflect the opinions and insights of key personnel associated with MaRCS who were interviewed by the Titan/SRD Team in October and November 2000. Those personnel had varying levels of knowledge about the MaRCS systems based on their involvement with system planning, development, implementation, or operational issues. Section 5., Recommendations, provides value-added perspectives from the Titan/SRD Team that seek to illuminate issues for management consideration in the planning of future systems.

Quality assurance procedures were applied to the design, implementation, analysis, and preparation of this report. The procedures encompassed methodology, specification of project procedures and software, computer system design and review, development of clerical and computer procedures, and data analysis and report writing. A description of the procedures used is provided in the "Census 2000 Evaluation Program Quality Assurance Process."

Study participants reviewed the results of this system requirements study. Comments have been

incorporated to the fullest possible extent.

3. LIMITS

The following limits may apply to this system requirements study:

- The perception of those persons participating in the interview process can significantly influence the quality of information gathered. For instance, if there is a lack of communication about the purpose of the review, less than optimal results will be obtained and the findings may lack depth. Each interview was prefaced with an explanation about its purpose in order to gain user understanding and commitment.

- In some cases, interviews were conducted several months, even years, after the participant had been involved in system development activities. This extended timeframe may cause certain issues to be overlooked or expressed in a different fashion (i.e., more positive or negative) than if the interviews had occurred just after system deployment.

- Each interview was completed within a one to two hour period, with some telephone follow-up to solicit clarification on interview results. Although a detailed questionnaire was devised to guide each interview and gather sufficient information for the study, it is not possible to review each aspect of a multi-year development cycle given the limited time available with each participant. Although this is a limitation, it is the opinion of the evaluators that sufficient information was gathered to support the objectives of the study.

- Every effort was made to identify key personnel and operational customers who actively participated in development efforts. In the case of MaRCS, all government personnel who participated in the study are still with the Census Bureau. The contractors interviewed for the study are still active on the MaRCS program.

4. RESULTS

This section contains findings that relate to the effectiveness of the requirements definition process used during the development of MaRCS. The requirements process establishes the foundation for a system and, as such, must be designed to thoroughly consider all technical and functional aspects of development and operation of the system.

4.1 Requirements definition

The original matching system was developed by in-house personnel. It was a character-based system that operated in a VAX environment. Versions of the system were used in the 1995 and 1996 Census Tests and the Census 2000 Dress Rehearsal. The system used in Dress Rehearsal

did not include the necessary functionality for person matching and, overall, was not sufficiently robust to meet the needs of the matching process. Given these shortcomings, and the limited availability of development resources within the Census Bureau, a contractor was selected to begin new development for the matching software.

The Housing Unit, Person, Final Housing Unit, and QA Teams had the primary responsibility for developing initial requirements for the matching software. Requirements were also subject to the decisions of the Design and A.C.E. Team Leaders teams. Requirements were provided to the contractor and further clarified during a number of off-site meetings. Agendas and meeting minutes were prepared for each of the meetings. The contractor developed detailed specifications, including screen mock-ups, from the initial requirements information. These detailed specifications were then used as the means to continue the review and refinement of the requirements with the subject matter teams. As development proceeded, team members evaluated the software and provided feedback to the developer. The same requirements definition and development process was used across the three MaRCS systems.

4.2 Requirements issues

4.2.1 Agency endorsed methodology was not available

There is no agency-wide development methodology to address requirements definition or system development within the Census Bureau. For MaRCS, cross-divisional teams were used to define the requirements. The contractor was mainly responsible for system development in meeting those requirements. Team meetings were conducted to identify and resolve issues and meeting minutes were prepared and distributed. Although no methodology was available as to the steps in preparing the required life-cycle documentation and the level of detail for each required document, the development effort was successful.

4.2.2 Major redesign occurred after Dress Rehearsal

The change from the dress rehearsal in-house system to the 2000 contractor-developed system required a completely new set of requirements. These requirements were developed during the timeframe when only minor revisions should have been made to the specifications and system used for dress rehearsal. Although the redesign was necessary, the subject matter teams had to work in a compressed window of time to develop a comprehensive set of requirements. Despite the additional workload created by the redesign, the system was deployed on-time and succeeded in accomplishing program goals.

4.2.3 No standard format existed for specification development

There was no single format for the development of initial requirements by the subject matter teams within the Census Bureau. Different teams prepared their requirements in different formats and the requirements were submitted in a piecemeal fashion. Although each subject matter team has unique needs and perspectives, a more structured and cohesive approach would

have simplified the specification development process. The contractor obtained much of the information needed from the initial requirements meetings and minutes. Although most of the requirements were defined up-front, design changes resulted in revised requirements that were addressed as they arose. This gave the impression that requirements were defined using a fragmented approach; this was often caused by changes outside the team's control, not from a lack of understanding as to what was needed. The contractor developed detailed specifications for the matching software from the user defined requirements. These specifications provide extensive detail on the system's functionality, process flows, hardware and software components, and other descriptive elements. These are excellent documents that can serve as the starting point for future requirements development exercises.

4.2.4 Iterative development takes advantage of lessons learned

Development of three distinct systems encouraged the application of lessons learned from each of the prior efforts since many of the same personnel worked on each successive system. Techniques and code used to develop certain functionality were applied directly to the subsequent systems. Also, processes involving requirements definition, team communication, and testing procedures benefited from the experience gained in the development of the initial system and were fine-tuned over time.

4.2.5 Complex/additional requirements impacted development

Targeted Extended Search (TES) was used on a small basis in dress rehearsal, then a decision was made to implement the process on a larger scale. This impacted the automation due to the complexity of TES and the fact that the function now had to be available to all users. The need to print housing unit followup forms was identified for dress rehearsal and was developed by Decennial Statistical Studies Division's (DSSD's) Computer Processing Team. Also, the need to print these forms in Spanish was a significant new requirement for the contractor that resulted in a modification to the contract. With the exception of the Spanish Housing Unit Followup form, all of the tasks above were delineated in the Statement of Work (SOW). The additional requirements, although complex, were necessary to conform to the design of the study.

4.2.6 TIRs used to identify and track changes

Census Bureau personnel used a Trouble Incident Report (TIR) system to identify and document problems or suggested changes to the MaRCS software. When a TIR was prepared, it was then numbered and summarized for discussion with the contractor. Prioritizing changes was fairly straightforward; issues regarding data quality were addressed first, issues regarding usability were addressed second, and cosmetic issues were addressed last.

4.3 Alignment with business processes

This section contains findings that relate to how well MaRCS supported the specific business

processes that were associated with the Census Bureau's need to support automated clerical matching of A.C.E. results with census information.

4.3.1 Software products appear easy to use

The Windows-based MaRCS software is easy to use and provides point and click functionality to facilitate the clerical matching process. The software is more streamlined than earlier systems allowing the clerks to move faster through the matching process. Technological improvements such as split screen, filter capabilities, and interaction with a map retrieval system developed by the Decennial Systems and Contracts Management Office (DSCMO) also enhance the system's usability.

4.3.2 System perceived as effective by study participants

Individuals involved with the system definition and development of MaRCS consider it highly effective in meeting the business needs of the Census Bureau. MaRCS was the "right system for the job" providing for a more efficient and effective matching process. A debriefing of NPC analysts was conducted to solicit detailed feedback on the system. Input from these personnel is essential as they have in-depth knowledge of the matching process and experience with both the Dress Rehearsal and Census 2000 matching software.

4.3.3 Skill requirements for matchers change with automation

The original matching process was a paper operation. Although the analytical concepts that are applied to the process are the same, the interaction of the clerk with computer-based matching software may add complexity. While requiring people to become proficient with technology, it provides a means for increased efficiency in the matching process. Computer-based matching impacted the skill requirements for clerks and required changes in the information and guidance used in the training programs and supporting user documentation. Some of the training staff tended to focus too heavily on the point-and-click aspects of the training rather than the actual matching itself.

4.4 System deficiencies

This section contains findings that relate to any specific shortcomings that were identified with respect to the system's ability to accomplish what it was supposed to do. Recognizing that 100 percent success is rarely achievable, it is still worthwhile to assess deficiencies in the spirit of constructively identifying "lessons learned." Such insights can greatly contribute to improvements in future system development activities.

4.4.1 Alpha testing conducted by more than one group

A separate group of personnel conducted alpha testing on the MaRCS software. This group prepared test plans, conducted the testing, and identified and documented problems for

resolution by the development contractor. Alpha testing improved the overall quality and functionality of the software; this was a result of the various teams responsible for alpha testing the different functionality of the MaRCS systems. The established alpha team was not capable of thoroughly testing the system so other personnel were assigned from outside the formal alpha team to test critical functionality (e.g., QA and batch software). Without these key personnel the system would not have been fully tested or operational in time for production. One possible downside to this process is the potential for the contractor to rely on the alpha testers to catch any problems which should have been identified as part of the developer's unit testing process.

4.4.2 MaRCS tested at Beta Test Site

MaRCS software was subject to the Census Bureau Beta Test Site processes and requirements. The Beta Test Site used a standard approach to evaluate the decennial systems; however, the requirements for submitting software and supporting documentation were not always clear to Census Bureau or developer personnel. The schedules used by the Beta Test Site did not allow for differences in the complexity of each of the systems. For complex software, the Beta Test Site personnel simply did not have the time to gain sufficient knowledge of each software package. This lack of understanding often resulted in mis-communication and identification of numerous problems, many of which did not affect the usability of the software.

4.4.3 Teams had limited experience with GUI interface

Census Bureau personnel had limited experience developing or using software with a Graphical User Interface (GUI) front-end. This caused some difficulties in the requirements definition process as the initial requirements were being expressed as they would be implemented within a character-based system. In addition, personnel involved in testing had limited experience with GUI, so test plans and procedures had to evolve to accommodate the uniqueness of the new software environment.

4.4.4 Multiple development tools were used

The MaRCS systems were developed using Visual Basic, SQL Server, and MS Access and operate in a Windows NT environment. SQL was used for the control files and Access was used for the data files. Crystal Reports and Grid Wiz are third party tools used to display and print system information. With the exception of problems encountered with upgrading Grid Wiz for added functionality, there were no major difficulties in integrating these tools during the development process or during deployment within the Census Bureau technology infrastructure. Despite the success of the application, there was some concern that Visual Basic is not sufficiently robust to address the GUI requirements for such a complex application. Also, NT appears to have some limitations with regard to the assignment and maintenance of user IDs.

4.5 Contract management practices

This section contains findings that relate to the effectiveness of contract administration activities.

Overall, even when system requirements are well-defined, ineffective management of contractors can lead to less than optimal results when a system is deployed. Consequently, it is beneficial to evaluate past practices in order to gain insights that can lead to improvements in system development efforts.

Contractors played a pivotal role in the development of MaRCS. After the Census 2000 Dress Rehearsal, the Census Bureau selected Gunnison to develop two separate applications that could be run in a Windows GUI environment. One of the applications was used for testing housing unit matching for the Master Address File/Quality Improvement Program (MAF/QIP); the other was used for post-Dress Rehearsal evaluations involving Clerical Person Matching (CPM). Due to the success of these applications, Gunnison was retained to develop a Windows-based version of MaRCS for A.C.E.

4.5.1 Contractor was experienced with census processes

Gunnison was uniquely qualified to develop the MaRCS systems. The contractor had extensive development experience and possessed an understanding of census operations from involvement in other census-related applications. Gunnison personnel worked closely with Census Bureau personnel to ensure the successful development of the MaRCS systems. Work was conducted on-site at the Census Bureau and at Gunnison offices.

4.5.2 Deliverables provided on a flow basis

The SOW contained dates and deliverables which were provided by the contractor on a flow basis. Some items in the SOW were identified at a very high level; these requirements required further clarification as the project progressed. In some cases, Census Bureau personnel could not provide comments to deliverables in a timely manner; in other cases, the extent of changes identified through this clarification process impacted the contractor's ability to meet its deadlines. Although some deliverables were submitted late, the products were delivered in sufficient time for testing. Any requirements that may have been misinterpreted were identified and resolved through the testing process.

4.5.3 Skill descriptions for software developers need review

The skill descriptions for software development labor categories used in some Census Bureau Requests for Proposal (RFP) may not be current given the new technologies and methodologies that can be applied to software development efforts. Skill descriptions used in Census Bureau contracts should be reviewed and updated to more accurately reflect the current technological environment (e.g., web-based technologies, dimensional modeling).

5. RECOMMENDATIONS

This section synthesizes findings from the above sections and highlights opportunities for

improvement that may apply to Census Bureau's future system development activities. The recommendations reflect insights from the Titan/SRD analysts as well as opinions regarding "lessons learned" and internal "best practices" that were conveyed by Census Bureau personnel during interviews.

5.1 Team building - conduct team training.

The Census Bureau used a team approach to develop and refine requirements for the MaRCS systems. Team members were selected from subject matter experts in stakeholder divisions: DSSD, Field Division (FLD), Geography Division (GEO), Technologies Management Office (TMO), DSCMO, and the NPC. Each team had a Team Leader responsible for collecting and coordinating initial requirements and feedback on the software as well as acting as a liaison between other teams. The selection and assignment of team members does not in itself guarantee that the team concept will work successfully. A clear definition of roles and responsibilities is necessary and guidance and training as to team development and communication is essential.

The development team had clearly established procedures for problem escalation. Issues that could not be resolved by a sub-team were discussed and usually resolved at the A.C.E. Implementation Team Leaders (TL) meetings. Issues not resolved at the TL meeting were presented and resolved at the A.C.E. Program Steering Committee (PSC) meetings. Any remaining issues were resolved by the DSSD Division Chief or upper management. This was documented on 2000 DSSD Procedures and Operations specification S-TL-05, section F.

Recommendation: Census Bureau personnel selected for team participation should receive training in team concepts and effective communication and participate in team building exercises with fellow team members. Although this would add time to the already compressed schedules for decennial system development, the knowledge and experience gained through these exercises would facilitate the exchange of information by encouraging interaction and welcoming the diversity of team members as a means to produce better systems and products. Problem escalation procedures should also be established and documented for times when teams cannot come to consensus or closure on issues among themselves.

5.2 Test planning - clarify roles and responsibilities.

Multiple layers of testing were applied to the MaRCS software. The testing was accomplished by the contractor, alpha test groups, team members, end users (analysts in the NPC) and the Census Bureau Beta Test Site. This approach provided for independent evaluations of the software but may have caused confusion in regards to the type of testing and documentation that was required from each group. When multiple groups share the testing responsibility for a system, care must be taken to clearly identify the roles and requirements of each group and procedures must be established to ensure an effective and efficient means of sharing test results.

Recommendation: SOWs prepared for system development efforts should document the type of

testing that is required of the contractor (e.g., unit testing, integration testing). Requirements for test plans and documentation should be included in the SOW and a specific approval process defined for the acceptance of the documentation by the government. In-house testing groups also require well-documented roles and responsibilities and a clear definition of the types of testing that will be accomplished for each system. The alpha test team should be reorganized to include personnel who can develop an in-depth understanding of the requirements and test more than just the GUI functionality. This will help ensure conformance to requirements specifications and comprehensive coverage of testing needs. Procedures to flow information between contractor and in-house testing groups should be established to facilitate communications and improve the overall effectiveness of the testing process.

5.3 Beta testing - communicate testing process.

MaRCS software was subject to the documentation and testing requirements of Census Bureau's Beta Test Site. The process consumed a significant amount of resources that otherwise could have been focused on continued development. The concept of application beta testing and system integration testing is accepted as an important means to ensure that a system is stable enough for deployment. However, the process used to implement the testing should be structured to facilitate the development and deployment process rather than impede it.

Recommendation: The mission and goals of the Beta Test Site should be clearly documented and well publicized to avoid any misunderstanding about the purpose and extent of the testing process. Project plans should include sufficient time for each software application and system to cycle through the testing process. Beta Test Site procedures should be well documented and readily available to both Census Bureau and contractor personnel. Key contact points within the Beta Test Site should be assigned to shepherd each system through the testing process. Open communication between Beta Test Site personnel and developers should be encouraged so that Beta Test Site personnel can quickly develop an understanding of the application and its components and developers can have access to a rapid means of identifying and implementing necessary changes.

5.4 System development methodology - establish standard life-cycle methodology.

A standardized methodology provides the agency with guidance for project planning and management and provides a contractor with direction for the technical approach, types of documentation, and level of detail appropriate for each phase of the development life-cycle. A typical methodology covers requirements definition, system design, development, testing, deployment, and on-going maintenance phases. A standardized methodology for system development would benefit the Census Bureau by establishing the structure and procedures for the specification and development of complex systems. A standard methodology would help to ensure the consistency and completeness of system development efforts.

Recommendation: Establish an agency-wide system development life-cycle methodology using input from other federal agencies and established industry standards. This methodology should

be implemented in conjunction with an organization devoted to standards and methodology development and to project management. Training and documentation should be made available to Census Bureau personnel and representatives from the new organization should be available to coach development teams through each phase of the development life-cycle.

5.5 Reliance on outsourcing - ensure business process objectives are met.

The use of contractor personnel appears to be essential for the Census Bureau to successfully deploy systems with complex technical requirements, as in-house development resources are reduced or diverted to other projects. Although many qualified contractors exist to augment the Census Bureau's expertise, it is essential for the Census Bureau to maintain control over contractor activities. In the case of MaRCS, Census Bureau Task Managers had the final authority for all decisions regarding the software systems.

Recommendation: A SOW may contain the appropriate verbiage regarding the role and responsibility of the contractor; however, Census Bureau personnel should retain the final decision making authority for planning, development, deployment, and maintenance issues. Input from the contractor is critical, but this input should be weighed carefully by in-house personnel to ensure that the agency mission and business process objectives are being met. The requirement for and the collection of detailed documentation from the contractor is key to providing an audit trail of development activities and to facilitate future development efforts of like systems. In addition, skill descriptions for system development labor categories should be reviewed and updated to reflect new technologies and methodologies. In the case of MaRCS, business process objectives were met and Census Bureau/contractor interface proved very successful; however, because of increasing reliance on outsourcing for system development, it is a best practice for the Census Bureau to carefully monitor and assess contracting issues to ensure business process objectives are met.

5.6 Change control process - expand formalized change control processes.

Census Bureau personnel used a Trouble Incident Report (TIR) system to identify and document problems or suggested changes to the MaRCS software. Tracking proposed changes is a critical part of change control, but it does not constitute a complete and formal change control process. The concept of a Change Control Board (CCB) is an effective means of identifying, assessing, prioritizing, and approving changes both in a development and production environment. Although a CCB can add some layer of bureaucracy to the development process, it is essential to ensure that any proposed changes are considered in light of the original requirements and available resources.

Recommendation: Require the use of formalized change control processes as part of all development efforts. Include representatives from each stakeholder organization on the board to ensure a fair assessment of the business and technical risks involved with each change. Changes should be systematically assessed in light of programmatic goals. The requirements for change

control and supporting documentation should be included in the system development methodology. The CCB also must have adequate resources to address programs with large and complex scopes.

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